Development of Dual-Axis Solar Tracking using Arduino

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A project report submitted in partial
Fulfillment of the requirement for the award of the
Degree of Master of Electrical Engineering

Faculty of Electrical and Electronic Engineering

Universiti Tun Hussein Onn Malaysia

January 2020

This master's project report is humbly dedicated to Almighty God, my father and my mother.

Thanks for your endless support!

ACKNOWLEDGEMENT

First and foremost, I give thanks to Allah, the most gracious, and most merciful for providing me this opportunity and granting me the strength and determination to complete my master program. I would like to thank my supervisor, Dr. Radzi Bin Ambar and co-supervisor, Dr. Norfaiza Binti Fuad for the patience, guidance, encouragement, and advice provided throughout my study. Your guidance helped me in all the time of my program and writing of this report.

To my lovely mother, the word alone cannot express my appreciation to you, I am indebted to all my lecturers that taught me. I would like to thank all my friends and course-mate from different countries for providing a stimulating and fun environment in which to learn and grow. Completing this work would have been more difficult if not for the supports and friendship provided by my family members, in-laws and friends. Limited spaces failed me to mention individual's name here. I am indebted to them for their help. Finally, I would like to thank the Iraqi government for granting me permission to study in Malaysia. Thanks very much.

ABSTRACT

Renewable energy sections are fast-spreading, as they can be considered new growth areas for many countries. Contains many economic and environmental possibilities. As solar energy is considered to have a major and effective role for the acquisition of energy, in the face of the identification of rural areas that are difficult to access electric power. The traditional solar power system used is produces weak energy by assumption that the sun is moving all the day, therefore requires the purchase of more solar panels refer to the high cost .The project aims to develop the traditional solar system to solar tracking system using Arduino, two servo motor and light dependent resistor (LDR) to obtain high efficiency in electric power generation. Where, the main goal agreed is to track the sunlight at its maximum intensity until the panel move towards the sun, and the project is divided into two main parts, the development of software and hardware. In hardware development will be used four LDR installed on plastic base on solar panel, connected wires to transfer the measurements from sensors to Arduino with resistances and Multi-meter to measure the required energy coming from the panel

ABSTRAK

Sektor tenaga boleh diperbaharui semakin mendapat landasan sebagai kawasan pertumbuhan baru bagi banyak negara dengan potensi yang luas yang dapat disampaikan kepada alam sekitar dan ekonomi. Tenaga solar memainkan peranan penting sebagai sumber utama tenaga, terutama untuk kawasan luar bandar. Sistem kuasa solar tradisional yang digunakan menghasilkan tenaga yang lemah dengan anggapan bahawa matahari bergerak sepanjang hari, oleh itu memerlukan pembelian lebih banyak panel solar merujuk kepada kos yang tinggi. Projek ini bertujuan untuk membangunkan sistem solar tradisional kepada sistem pengesanan solar menggunakan Arduino, dua motor servo dan perintang yang bergantung kepada cahaya (LDR) untuk mendapatkan kecekapan tinggi dalam penjanaan kuasa elektrik. Selain itu, matlamat utama projek ini adalah untuk mengesan sumber cahaya matahari maksimum untuk memancarkan panel solar. Projek ini dibahagikan kepada dua tahap, iaitu pembangunan perkakasan dan perisian. Dalam pembangunan perkakasan akan digunakan empat LDR yang dipasang pada asas plastik pada panel solar, kabel yang disambungkan untuk memindahkan ukuran dari sensor kepada Arduino dengan rintangan dan Multi-meter untuk mengukur jumlah tenaga yang datang dari panel.

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CHAPTER 1

INTRODUCTION

1.1 Project background

The demand for energy is daily growing. But, due to their limited resource and environmental unfriendliness, conventional or non-renewable materials like oil, gas, and coal are less important these days. In the near future, the problem will be more acute. Normal solar cells convert around 30 to 40 % of solar ray's to energy as outcome [1]. The energy like the sun supposed to finish from the ground and in this century it often leads to problems that are difficult to solve in supporting humanity to produce acceptable and fully reliable energy sources.

Renewable energy is clean and inexhaustible. Energy resources such as the sun, geothermal heat, waves, wind and tides. Climate changes could be noticed within the effect of natural phenomena on agriculture in particular and serious weather conditions all over the world [2]. Energy from bright light and heat from the sun’s solar ray can be harvested using technology like photovoltaic cells. Air pollution could be get rid of by solar energy, where it is friendly to the environment. Furthermore, solar system based energy is ceaseless source. This work is focusing on improving the existing solar tracking system for harvesting solar energy motivated by Malaysia's weather that can be categorized as equatorial, being humid and hot around the year.

1.2 Problem statement

Solar system energy harvesting performance depends on the amount of the energy that could be generated. The solar energy source is the most unfailing, where the source of energy is known to humanity [3]. The sunlight's direction is not stationary but it moves from period to period, according to the sun's movement. The problem here is the conventional home and residential solar power system used only solar panels in fixed installations. Due to this issue, the harvested electricity that could be produced is low. The other issue is that to design a tracking system will often be relatively high cost especially when harvesting more solar energy because it requires installing more than one panel for producing sufficient electricity. So this research is to solve the described issues. The proposed solar tracking design could make a 180 degree turn on two dimensional. Therefore, the solar tracking system that can be created here is capable of generating more energy in comparison to fixed design. The panels at most made of semiconductors, specifically silicon, the efficiency is 24.5% on the up side [4].

1.3 Objectives

1. To develop a dual axis solar tracking using mechanism electric motors and Light Depending Resistance (LDR).
2. To demonstrate the effectiveness of the dual and LDR sensor to detect light source.
3. To verify the performance of a dual axis solar tracking design and compared to static solar tracking design via experiment.

1.4 Scope

The scope is the definition of this research.

1. The type of the solar panel is Polycrystalline which contains a huge number of coherent crystals, it is the only source of light energy acquisition.
2. Axis rotation greatly facilitates to movement the solar system giving the ease exploitation the sun energy by adding two motors.

3. The main chip using in the project is Arduino Uno where the characteristics of this chip are flexible for programming editing.

The importance matter to understanding and studying the tracking system and how it works, but the working knowledge of the principle of this project it will be easy to know how to reasoning energy get it and connect it to reasoning power supplies, However, the important part to know is how the motors work and are directed by the Arduino segment.

1.5 Project justification

The research is carried out to catch the sun's rays using a photovoltaic panel to produce highest energy. This is exploited into electrical energy. The suitable harvesting period is in the midday between 1200 to 1400 hours. At this time the sun is 90 degree vertical, in this case the system must use the least energy provided until the panel moves towards the sun, and the efficiency of the system will increase. The design which is accurate and economical, the basis of this work depends on the microcontroller, which was recently implemented through the time allocated, with available supplies. It is expected to track and detect the sun's ray. For saving energy, during the night time, where horizontal mode is required when stopped, there is an application of an algorithm that processes the required movement that was previously programmed in C language.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

A solar system tracker is a machine applied to direct solar panels or to focus lens or reflector toward the sun light. The location of the sun is changed both with the time day and seasons movement of the sun. To improve the structure of energy consumption, to decrease the reliance on fuels fossil, the trends of energy development have become the different countries of the world [5]. These solar energy devices, where they are best when they are directly facing to the sun. Therefore, the solar tracker increases the efficiency of this device in any fixed position, which reduces the added complexity of the system. The most prosperous source of energy itself solar energy [6].Various types of tracking devices with the availability of optical technology and the powerful development of sun protection, it has become possible to obtain solar energy. Semiconductor material from which it is made the solar cell is made to converts the fallen light into energy, using the sunbeam. A number of cells connected to electricity, generates DC energy sources that can be used to charge. Solar usage is increasing because efficiency is high [7]. Where in devious area most common with no internet. Light energy is obtained from the sun. The photovoltaic solar cell is a technology it will converts the solar energy directly into electricity. The photocell is a non-silicone alloy device.

2.2 Rotation of earth with revolution

The earth is considered one of the most important planets that the sun embraces and revolves around it, where the rotation is around the same axis and there are two common movements from west to east around its axis. The ground line is not real, passing through the south and North Pole, as the earth completes its rotation within 24 hours. The campaign is responsible for day and night activities. A sunny day is 24 hours and a working time of the difference here is in the 4 minutes, as 23 hours and 56 minutes have a difference in this situation associated with a change in the position of the Earth compared with sun. Figure 2.1 shows the earth rotation around its axis.

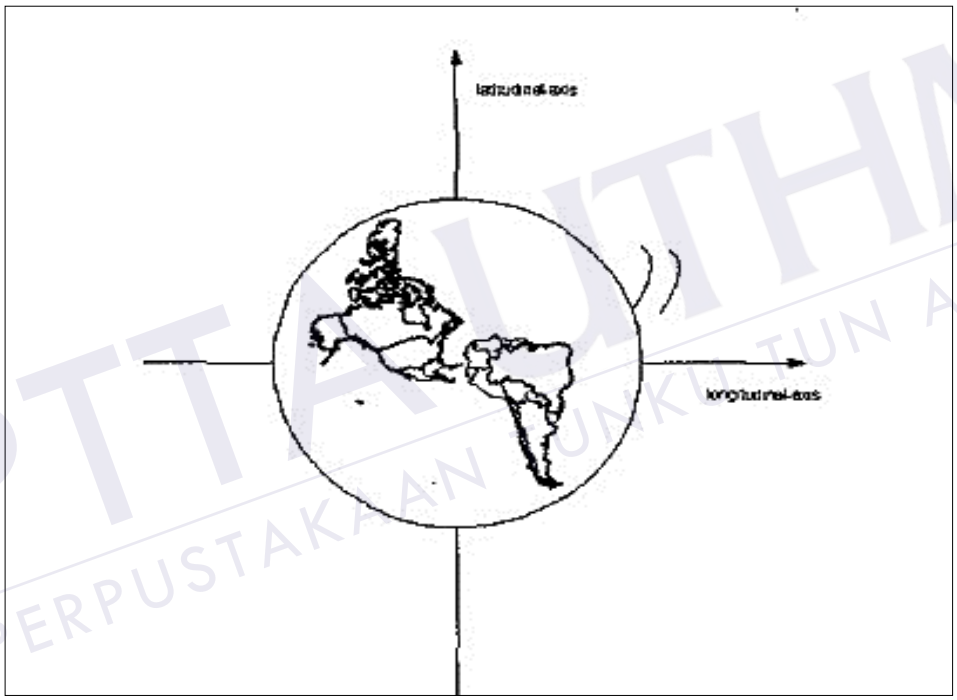

Figure 2.1: The earth axis of rotation [8].

2.3 The basics process of the solar tracking system

Light is consists of photons and a little amount of energy flows through a solar cell panel that provides electrical power through the action of the sun's rays. The drive will charge when the system is within range and we can use it in many other applications. The effect of temperature on PV performance is relatively important because the effects of temperature need to be considered when designing and controlling the system [9].

2.3.1 Solar tracker

Solar energy monitoring is a common technique the efficiency of the system depend on the expansion of the solar batteries, in this case will increases the system producing. The intense sunbeam stacked by panel and installed on the monitoring system is longer than the critical radiation levels of more stable systems. There are different collectors of different costs, performance and complexity. The collector consists of photovoltaic cells. There are fixed solar panels and universal and axial solar panels, as shown in Figure 2.2 it is estimated to increase the productivity of solar panels by 30-60% using a monitoring system instead of a fixed line [10]. With variable height solar collector, it can generate more than 40 percent extra energy each year. To make the panel face the sun, we use a device intended for this position. The location of the sun varies with respect to the evening, depending on the day and the time [11].

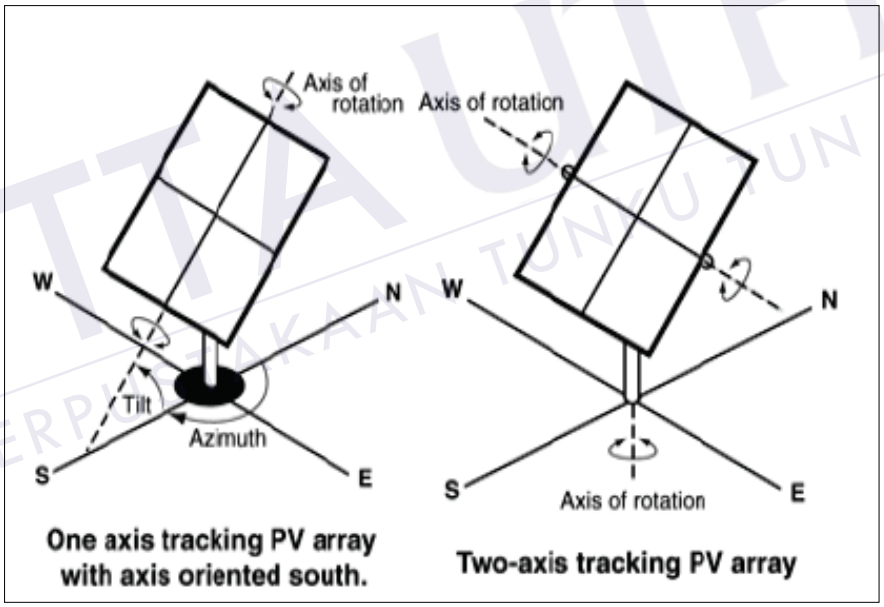

Figure 2.2: First and second dual axis solar tracking [12].

2.3.2 Solar tracking system

Solar tracking system is one of the transformations energy of light into energy of electrical, the solar tracking is a device its function to produce electricity, other term photo cell. It collects the light that reaches the board through solar panel, preferably the model is square, to simple installing. Figures 2.3 shows the mechanical structure of the tracking system.

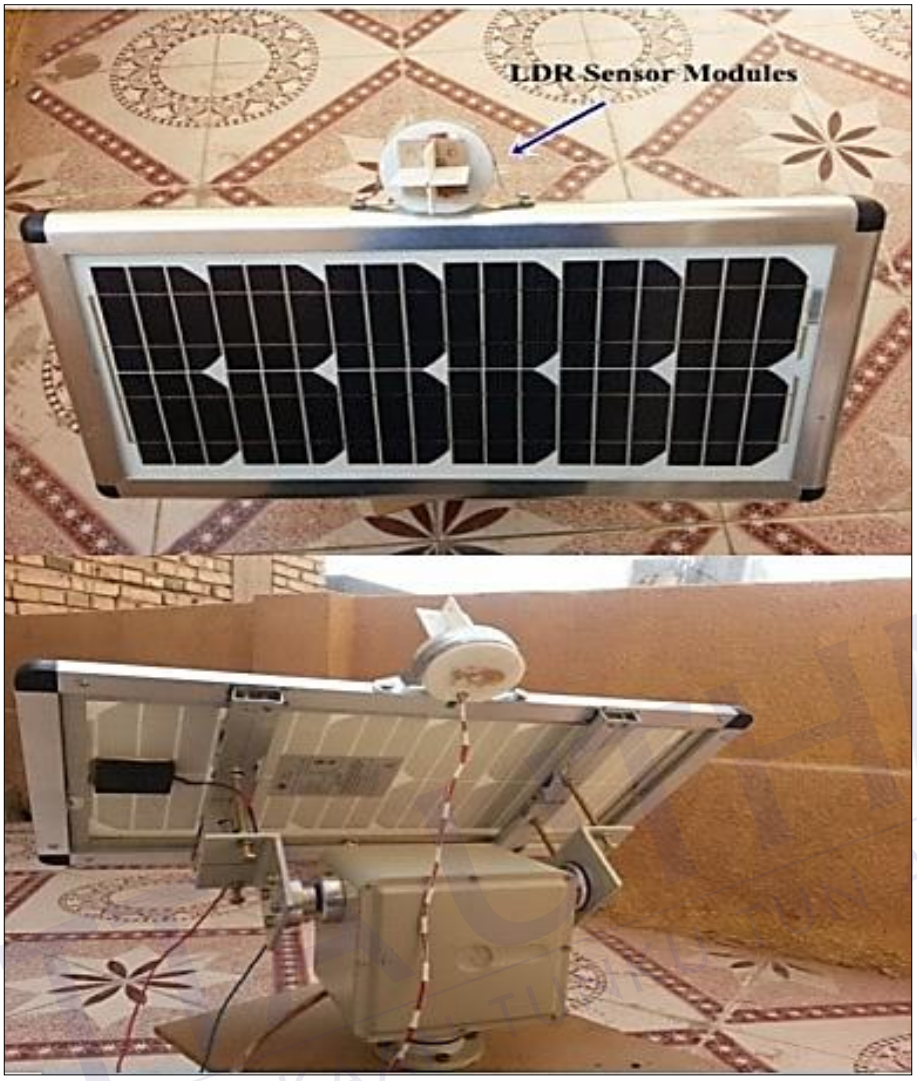

Figure 2.3: Mechanical structure of the tracking system [13].

2.3.3 Solar energy

Solar energy is radioactive energy absorbed from sunlight. It provides all its energy to the world as all living things depend on it, necessary for the supply of fixed energy. In order to provide constant power in all of the world, solar energy is stocked in fuel fossil, which will be in charge of for running water cycle and producing wind. Where it can be said that the sun has a beam daily and this will have a huge amount of energy, renewable energy are one of the types of solar energy. In order to solve this problem, the government took the initiative to solve this problem [14]. The source of solar energy is continuing that means generating energy for billions of years. Figure 2.4 demonstrate the solar energy falling on the PV panel.

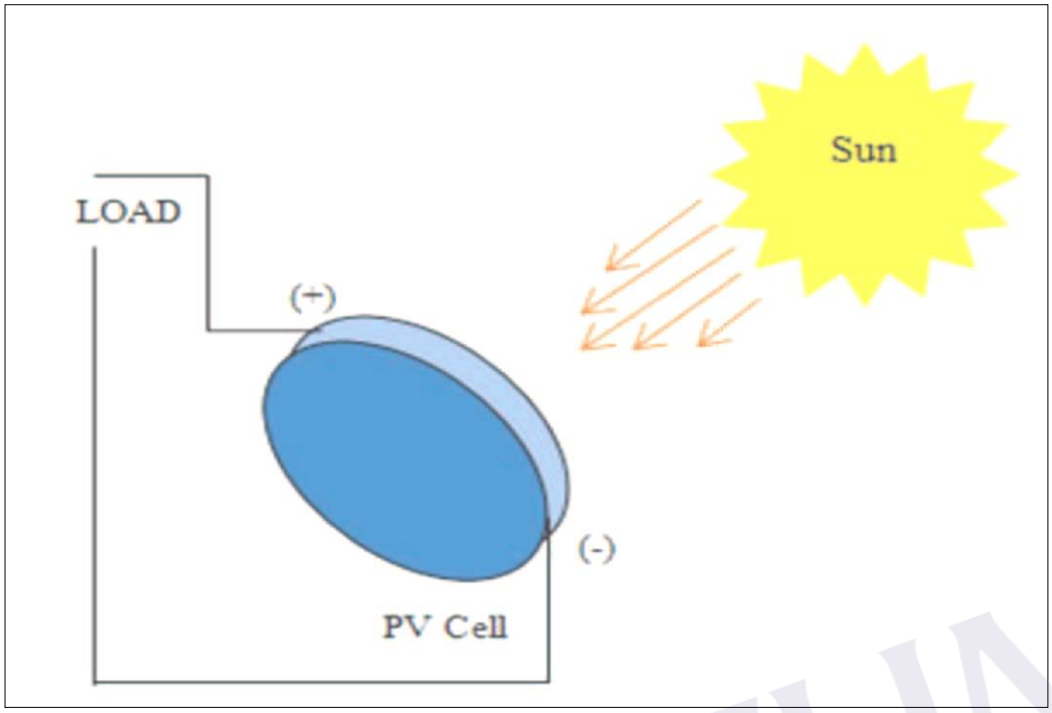

Figure 2.4: Diagram of Photovoltaic Technology [15].

2.3.4 Solar cell

Solar cell is often called as photovoltaic (PV) cell where it was discovered by the physical French Edmund Becquerel, where they found that the output of the voltage in one of the poles in a similar solution is weak, and the solar cell can generate an electric current by semiconductor devices. It is known that the semiconductor material in which the photon moves as a component of light enhances electrons to move towards the external circuit [16]. Electricity will be produced when the light falls in the solar cell. Single-crystal silicon is a type of solar cell. Silicon is an intrinsic semiconductor where this substance is used in the solar cell and in its purest form when a small amount of impurities is included, where semiconductor density increases. There are two types of photovoltaic cells, the first is a mono-crystal silicon solar cell, and the solar cell is made from Si or Mono-crystal Si can be easily combined from the outside. Furthermore, a mono-crystal silicon solar cell is made of an identical cylindrical silicon alloy, indicating a high purity of silicon to increase productivity and reduce the cost of Mono-crystal solar cells. The second type is Poly-crystalline silicon solar cells, also known as Polysilicon (p-Si) and Polysilicon (mc-Si). Unlike single-crystal silicon solar panels, the original silicon melted and poured into a mold square.

Table 2.1: Differences between Poly and Mono [17].

VOC	ISC	Type
21.2 V	9.17 A	Poly
22.5 V	8.71 A	Mono

Table 2.1 shows the differences between Polysilicon and Mono-crystal solar cells in term of short-circuit current (ISC) and voltage open circuit (VOC). It shows Mono-crystal superiority over the Polysilicon because of its high voltage.

2.3.5 Photovoltaic effect

The photo-voltaic impact could be explained as a production of electromotive energy and through the field of non- heterogeneous materials during illumination with the suitable wavelength. Often, this effect is increased and electromagnetic radiation can be converted into electricity. The semiconductor components have the ability to take a large amount of solar phantom. Based on the absorb specifications of the raw material the light is taken in a zone more or lesser near to the surface [18]. The PV cell converts the light from the sun into electricity, known as the basic physical process, and PV operates at any time of sunrise, when the light is more intense, the electricity output it will a high rate.

2.4 Design of minimum length of reflector

As the weight of whole system ultimately dictates the load on tracking motor, while designing the reflector two things were considered: the weight of the reflector and to evenly distribute the reflected rays over the panel to avoid uneven voltage generation. In order to make it so swift weight it was significant for reducing its size by computing the smallest leaning the mirror length. From the laws of reflection of light, the geometry of light rays with booster mirror (BE) and PV panel (BC), it was observed that if the mirror is fixed at an angle of 120° with the panel then it will cover the whole panel surface in AB side. The sides AB and CD are similar in dimension so the mirror size was same for that two sides. The height of the mirror was calculated as 29 cm. The same analogy was applied for side AD. Figure 2.5 illustrate geometry of light ray with boosted mirror and PV panel.

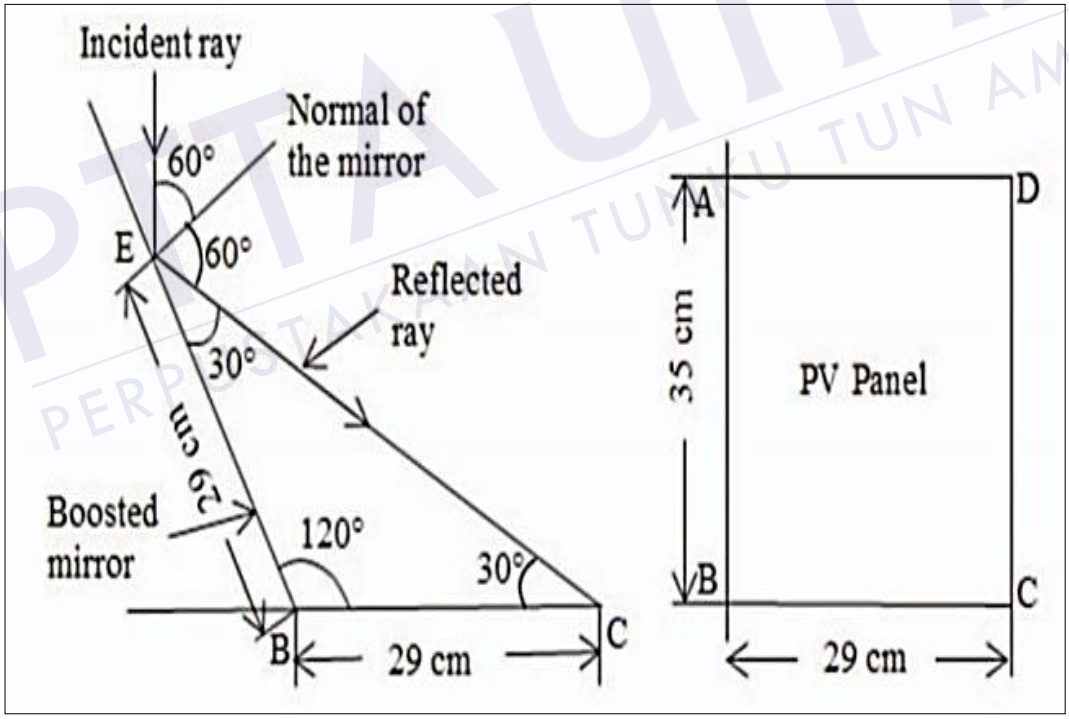

Figure 2.5: Geometry of light ray with boosted mirror and PV panel [19].

2.5 Servo motor

The movement of solar panel in this work is controlled using servo motors to ensure appropriate speed and acceleration of motions [20]. It consists of two small and convenient servo motors to move the panel on pan and tilt motions.

There are various types of servo motors. Some requires relatively advanced controllers, usually special units servo motors are specially designed for them and are not only motors or for a specific class. Sometimes the term servo motor is used to control the closed loop. In servo motors it is used for monitoring and controlling, and entering values is like controlling the signal, which indicates the position required for the output column. The engine depends on an encryption type to find the speed and return. In the simplest case, then the situation is measured on the control unit, where the command position is compared to the measured position and the values external input. If the required position is completely different with the output position, an error signal is generated to determine the correct position, causing the motor to rotate in either direction.

As the situation approach, the fault signal goes to zero. The simplest servo motor potentiometer and motor only use position sensors controlling the sound of the explosion, the engine always turns (or stops) at full speed. This servo tool is not widely used in the field of industrial traffic management, but it is a simple and economical server base for radio management models. The most advanced, servomotor use an optical rotation encoder to measure the output shaft speed and the variable speed controller for speed control. In general, both tools together with the PID control algorithm it allows command of position more quickly and precisely in direction. Figure 2.6 shows the pulse width modulation diagram.

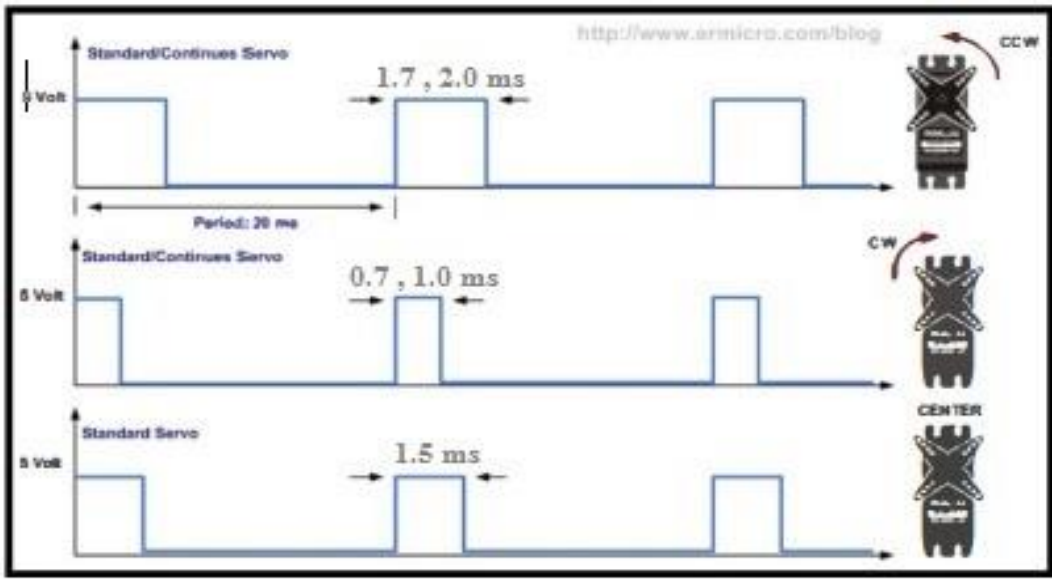

Figure 2.6: Servo motor pulse width modulation timing diagram [21].

2.5.1 Theory of servo motor

In some special motor specific application types, the motor must only be rotated at an angle without the need for continuous rotation over an extended time. Specific types of special motors are needed, and specific configurations are provided to rotate the motor at an angle for a provided input. Typically, this is a single controlled DC current used for a given angular rotation using an additional servo. Current servo systems have huge industrial applications. Influential drives are also common in remotely controlled minivans, which control the direction of travel. In addition, we have hundreds of other applications in our daily lives. The key cause for utilizing servo devices is that it provides angular accuracy. It would only turn to the desired range, next it stops and waits for the coming signal for doing further action. This engine differs from the normal engine that starts and continues to run when the power is turned off. We cannot control the motor rotation and cannot control the rotation speed, but it can be turned off and on.

2.5.2 Servo-mechanism

The electrical system consists of three essential components - the control device, the output sensor and the feedback system. It is an automatic closed loop control system.

Instead of controlling the device by changing the input signal, the feedback signal is controlled by comparing the output signal with the input signal. When using the input signal or directional signal in the system, it is compared to the output signal generated by the output sensor and the third signal from the feedback system. The third signal is used as the input signal for the controlled device. As long as there is a reasonable difference between the input signal and the system output signal, the input signal is provided to the device. Once the device has reached the required outcome, there is no comparison among the input reference signal and the system reference output signal. Thereafter, comparing the weights of the above signals will result in a third signal that is insufficient to further power the device and generate more system output till the following or command signal is developed to the system. Therefore, the main function of the servo is to keep the outcome of the system at the required result in the presence of interference. Figure 2.7 shows structure of the servo motor system.

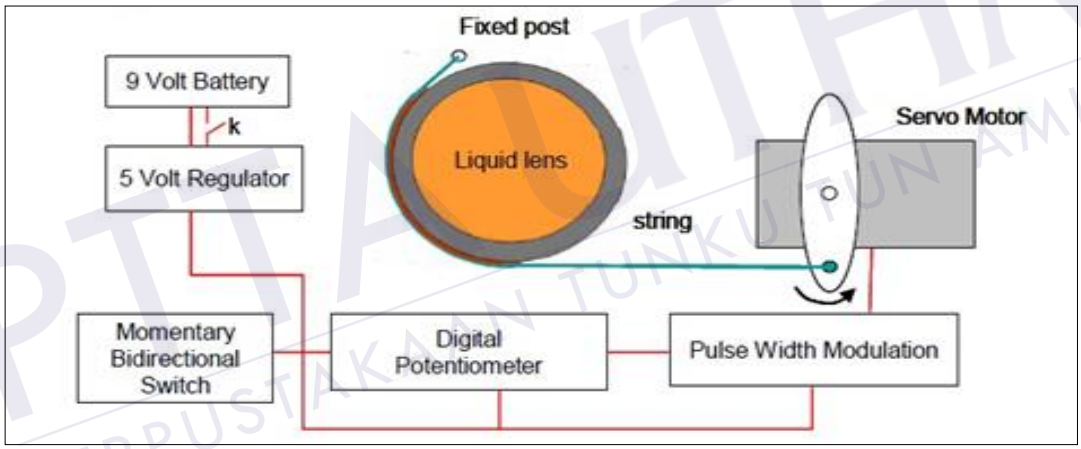

Figure 2.7: Structure of a servo system [22].

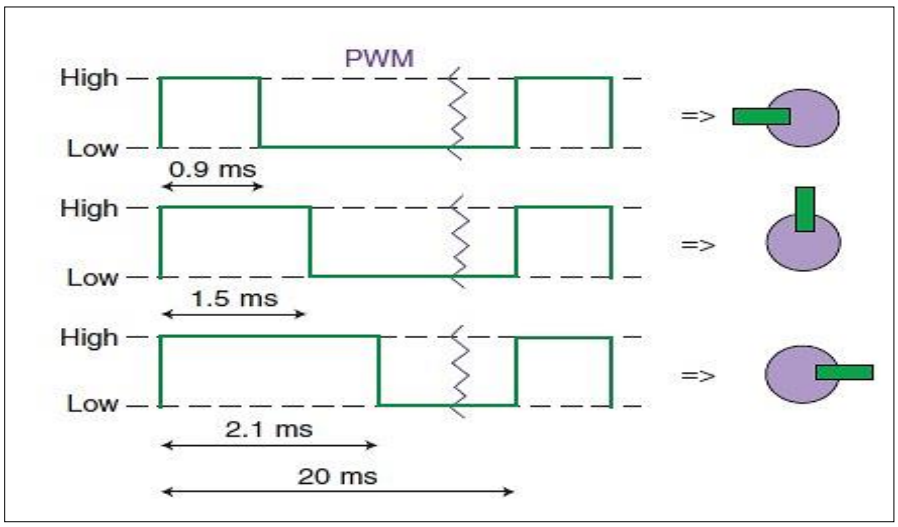

Figure 2.8: Controlling servo with PWM [23].

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